midlatitude flight corridor. NO_x is effective in destroying ozone (O_3) in a well-known catalytic cycle that can proceed rapidly under stratospheric photochemical conditions.

Several results from research carried out with the Argus instrument are described below.

Tracer Laminae in the Tropics – Transport of air from the midlatitudes into the tropics in the stratosphere is known to be inhibited by a "transport barrier." The existence of such a barrier was already well known from satellite studies of dispersion of the Mt. Pinatubo aerosol cloud, following Pinatubo's eruption in June, 1991. On the other hand, some transport of stratospheric air into the tropics is known to occur from the detailed study of tracer mean vertical profiles in the tropics. Interest in this issue centers on the fate of aircraft exhaust products injected into the midlatitude stratosphere, and their potential impact on the tropical ozone production region.

During an OMS balloon launch from 7° S in Brazil in November, 1997, thin laminar regions of low N_2O on the normal tropical profile of this tracer were observed. (N_2O is lower in the midlatitude stratosphere than in the tropics at the same altitude.) The data indicated clearly midlatitude values of N_2O in the tropics. This appears to be a direct observation of the process of rapid transport into the tropics of midlatitude stratospheric air masses. The observations suggest that this transport is episodic, possibly the result of breaking of midlatitude stratospheric waves (Rossby waves).

Long-Lived Arctic Winter Vortex Remnant – During an OMS balloon launch (in conjunction with ER-2 flights) from Fairbanks, Alaska, in late June, 1997, several layers of unusually low values in the N_2O and CH_4 tracer fields were encountered. These were clearly "remains" of the winter polar vortex with the observed filaments preserving very low tracer values characteristic of the interior of the vortex which had subsided from higher altitudes during the previous winter. The unusual, possibly unique, quality of the discovery was that these layers had maintained their integrity for about two months, from the time of vortex breakup sometime in late April until their observation in late June.

Intercomparison Flights with ATLAS and Other Tracer Instruments – Plans to design a new ER-2 instrument or to fly Argus on the ER-2, in both cases for the purpose of replacing the older and heavier ATLAS instrument, has motivated two separate flight intercomparison campaigns. In the fall of 1998, Argus and ATLAS flew together on the ER-2 in an otherwise unrelated atmospheric radiation campaign called CiRex (Cirrus Radiation Experiment). In the fall of 1999, a comparison of several N_2O instruments was carried out in preparation for the SOLVE (SAGE II Ozone Loss and Validation Experiment) Arctic Ozone mission to take place in January through March of 2000.

Both of these intercomparison campaigns provided an opportunity to pass the pedigree of N_2O tracer field measurements made by ATLAS, and widely accepted as a standard in the ER-2 airborne measurement community, on to the new Argus instrument. The importance of this transfer is the significant weight reduction realized by the dual channel Argus instrument, thus allowing space for additional payload in the wide-ranging ER-2 atmospheric chemistry payload suite.

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TRMM/ Large-Scale Biosphere Atmosphere Experiment in Amazonia (LBA)

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The TRMM/LBA mission was conducted in January and February, 1999, from several sites in the lower Amazonian region of Brazil. TRMM is the Tropical Rainfall Measuring Mission satellite. The experiment was conducted as part of the larger umbrella mission, Large-Scale Biosphere/Atmosphere Experiment in Amazonia (LBA). TRMM/LBA was one in a series of global field experiments that were planned to obtain ground validation measurements in support of the TRMM satellite mission. The objective of the field campaign was to obtain measurements for a tropical continental site, which would provide for the validation of the physical assumptions required for the retrieval of precipitation data from the satellite. To obtain these measurements, TRMM/LBA employed a large and complex suite of measurement platforms deployed to Brazil. The instrumentation consisted of two ground-based Doppler radars, two research aircraft, special radiosonde sites, a vertical profiler, tethersonde, meteorological flux tower, and an array of radiometers, rain gauges, and disdrometers for measuring rainfall drop size distributions.

The TRMM satellite carries two primary instruments for obtaining precipitation measurements from space: a passive microwave instrument, the TRMM Microwave Imager (TMI), and the Precipitation Radar (PR). These are the primary instruments for which validation data are required.

The focus of the field measurements was the dual Doppler coverage of the two ground-based radars. One radar was the S-band, polarizing radar from the National Center for Atmospheric Research in Boulder, Colorado. The other was the C-band radar from NASA Wallops Flight Facility in Virginia. The two radars were installed just outside of the city of Ji-Parana in the western state of Rodonia, Brazil. The objective was to make the aircraft measurements within the overlapping, dual Doppler coverage of the two radars. The aircraft used were the NASA ER-2 and the University of North Dakota Citation. The ER-2 carried remote sensing instruments to act as a surrogate satellite, and in situ cloud physics instruments to obtain direct measurements of the cloud drop size distributions. The ER-2 was based in Brasilia, which is approximately 1500 kilometers (km) east of the ground site at Ji-Parana. The Citation was based at an airfield in Porto Velho, which is approximately 100 km west of Ji-Parana. The Citation carried in situ instrumentation for obtaining detailed microphysical data in clouds and precipitation. With the aircraft and ground-based instrumentation, it was possible to obtain a complete three-dimensional picture of the structure and dynamics of the precipitating cloud systems. The microphysical data provided detailed information on the state (liquid or ice) and size distribution of the precipitation.

TRMM/LBA was a collaborative mission between NASA and the Brazilian Space Institute (INPE), with significant participation from the University of Sao Paulo. In addition to the NASA mission, a large European effort was conducted concurrently in close coordination with TRMM/LBA and the Brazilian scientists. TRMM/LBA participants came from NASA, the National Oceanic and Atmospheric Administration (NOAA), the National Center for Atmospheric Research (NCAR), and several universities and private research companies. The Earth Science Project Office at Ames Research Center managed the field campaign; NASA participants came from Goddard Space Flight Center, Marshall Space Flight Center, and Jet Propulsion Laboratory. The overall scientific direction of the project was provided by S. Rutledge, Colorado State University.

The primary focus of the mission was on the ground instrumentation sites in and around Ji-Parana. Both aircraft left their respective airfield bases and flew over the radar coverage area around Ji-Parana. In addition to the large radars, the NOAA's Aeronomy Laboratory set up wind profilers at the airport in Ji-Parana. These were vertically pointing radars that obtain wind profiles from the surface to about 10 km. NASA Goddard and the University of Iowa provided video disdrometers that use high-speed digital cameras to obtain rainfall-drop-sized distributions. Many surface rain gauges were distributed in concentrated networks to obtain the spatial distribution of rainfall. The University of Virginia (UVa) supplied a tethered balloon system that made continuous vertical profiles of the basic state variables and wind components from the surface to 1500 meters. UVa also set up and operated a meteorological tower and an acoustic sounder, which were set up in a large pasture down the hill from the C-band radar.

The mission was successful. Precipitation was plentiful, the instrumentation worked well, and the radars were operated 24 hours per day, seven days per week. The experiment used 100 ER-2 flight hours and approximately 60 Citation flight hours.

Collaborators in this research include Ramesh Kakar (NASA Headquarters), Steven Rutledge (Colorado State University), Quincy Allison (SIMCO Electronics), Steve Gaines and Joe Goosby (Raytheon Corp.), Betty Symonds (Science Applications International Corporation), and Sue Tolley (SIMCO Electronics).

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